# Equation de Poisson 2D

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Master : Energétique

Matière : Méthodes Numériques Appliquées I

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Détermination de la temperature $T(x, y)$ à travers la surface d'une plaque rectangulaire (a x b) dont les 4 extrémités sont soumises à des (C.L.) de Dirichlet et contenant une source de chaleur au centre.

$$\frac{\partial^2}{\partial x^2} T(x, y) + \frac{\partial^2}{\partial y^2} T(x, y) = -\frac{Q}{\lambda}$$

Conditions aux limites (C.L):

$$\begin{aligned} T(x, 0) &= 0, \\ T(x, b) &= 0, \\ T(0, y) &= 0, \\ T(a, y) &= 0. \end{aligned}$$

**Solution discrétisée par la formulation à 5 points:**

```
> Restart :
> a := 5 : b := 15 : ndx := 20 : ndy := 30 :
> β := 1. :
> Δx := a/ndx ; λ := 0.4 : Q := 40 :
```

$$\Delta x := \frac{1}{4} \qquad \textbf{(1.1)}$$

```
> i_max := ndx + 1; j_max := ndy + 1;
```

$$i_{max} := 21$$

$$j_{max} := 31 \quad \textbf{(1.2)}$$

**Nombre d'équations:**

```
> N := (i_max - 2)·(j_max - 2)
```

$$N := 551 \quad \textbf{(1.3)}$$

**Maillage:**

```
> with(GraphTheory) : with(SpecialGraphs) :
> G := GridGraph(i_max, j_max)
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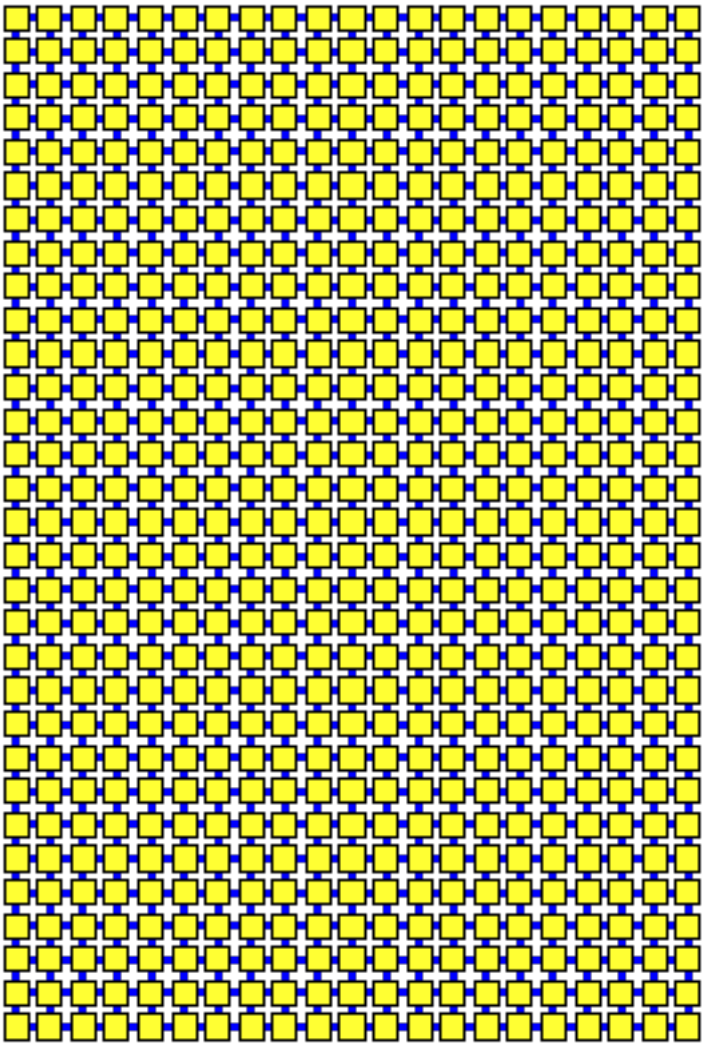
$$G := \text{Graph 1: an undirected unweighted graph with 651 vertices and 1250 edge(s)} \quad \textbf{(1.4)}$$

```
> DrawGraph(G)
```



**Conditions aux Limites:**

```
> for i from 1 to i_max do T[i, 1] := 0 end do:
> for i from 1 to i_max do T[i, j_max] := 0 end do:
> for j from 1 to j_max do T[1, j] := 0 end do:
>  for j from 1 to j_max do T[i_max, j] := 0 end do:
> k := 1 :
```

**Résolution pour les noeuds internes**

```
> for i from 2 to i_max - 1 do
    for j from 2 to j_max - 1 do
        Eq[k] := T[i + 1, j] + T[i - 1, j] + β^2·(T[i, j + 1] + T[i, j - 1]) - 2·(1 + β^2)
```

$$\cdot T[\mathrm{i},\mathrm{j}] + \Delta x^2 \cdot \frac{Q}{\lambda} = 0;$$

$Temps[k] := T[\mathrm{i},\mathrm{j}];$

$k := k + 1$

**end do;**

**end do;**

**Ecriture du système d'équations:**

> $Eqs := \{seq(Eq[\mathrm{i}], i = 1..\mathrm{N})\}:$

> $Tmps := [seq(Temps[\mathrm{i}], \mathrm{i} = 1..\mathrm{N})]:$

> $SolT := solve(Eqs, Tmps);$

$SolT := [[T_{2,2} = 11.29787266, T_{2,3} = 19.48363808, T_{2,4} = 25.80514549, T_{2,5} = 30.85517014, T_{2,6} = 34.96251618, T_{2,7} = 38.33258831, T_{2,8} = 41.10494466, T_{2,9} = 43.37990059, T_{2,10} = 45.23217708, T_{2,11} = 46.71852040, T_{2,12} = 47.88224531, T_{2,13} = 48.75607715, T_{2,14} = 49.36398305, T_{2,15} = 49.72235820, T_{2,16} = 49.84076825, T_{2,17} = 49.72235820, T_{2,18} = 49.36398305, T_{2,19} = 48.75607715, T_{2,20} = 47.88224531, T_{2,21} = 46.71852040, T_{2,22} = 45.23217708, T_{2,23} = 43.37990059, T_{2,24} = 41.10494466, T_{2,25} = 38.33258831, T_{2,26} = 34.96251618, T_{2,27} = 30.85517014, T_{2,28} = 25.80514549, T_{2,29} = 19.48363808, T_{2,30} = 11.29787266, T_{3,2} = 19.45785256, T_{3,3} = 34.58153416, T_{3,4} = 46.63177376, T_{3,5} = 56.40301890, T_{3,6} = 64.41230628, T_{3,7} = 71.01289240, T_{3,8} = 76.45728972, T_{3,9} = 80.93248063, T_{3,10} = 84.58028732, T_{3,11} = 87.50965922, T_{3,12} = 89.80438368, T_{3,13} = 91.52808024, T_{3,14} = 92.72749686, T_{3,15} = 93.43468151, T_{3,16} = 93.66835661, T_{3,17} = 93.43468151, T_{3,18} = 92.72749686, T_{3,19} = 91.52808024, T_{3,20} = 89.80438368, T_{3,21} = 87.50965922, T_{3,22} = 84.58028732, T_{3,23} = 80.93248063, T_{3,24} = 76.45728972, T_{3,25} = 71.01289240, T_{3,26} = 64.41230628, T_{3,27} = 56.40301890, T_{3,28} = 46.63177376, T_{3,29} = 34.58153416, T_{3,30} = 19.45785256, T_{4,2} = 25.70200341, T_{4,3} = 46.50287224, T_{4,4} = 63.48739648, T_{4,5} = 77.46282541, T_{4,6} = 89.02079763, T_{4,7} = 98.59938528, T_{4,8} = 106.5288412, T_{4,9} = 113.0624449, T_{4,10} = 118.3968323, T_{4,11} = 122.6854455, T_{4,12} = 126.0475500, T_{4,13} = 128.5743632, T_{4,14} = 130.3332427, T_{4,15} = 131.3705143, T_{4,16} = 131.7132952, T_{4,17} = 131.3705143, T_{4,18} = 130.3332427, T_{4,19} = 128.5743632, T_{4,20} = 126.0475500, T_{4,21} = 122.6854455, T_{4,22} = 118.3968323, T_{4,23} = 113.0624449, T_{4,24} = 106.5288412, T_{4,25} = 98.59938528, T_{4,26} = 89.02079763, T_{4,27} = 77.46282541, T_{4,28} = 63.48739648, T_{4,29} = 46.50287224, T_{4,30} = 25.70200341, T_{5,2} = 30.59728883, T_{5,3} = 55.99055493, T_{5,4} = 77.10211451, T_{5,5} = 94.69008864, T_{5,6} = 109.3586735, T_{5,7} = 121.5850099, T_{5,8} = 131.7462449, T_{5,9} = 140.1416254, T_{5,10} = 147.0091517, T_{5,11} = 152.5377404, T_{5,12} = 156.8760074, T_{5,13} = 160.1385801, T_{5,14} = 162.4105962, T_{5,15} = 163.7508380, T_{5,16} = 164.1937954, T_{5,17} = 163.7508380, T_{5,18} = 162.4105962, T_{5,19} = 160.1385801, T_{5,20} = 156.8760074, T_{5,21}$ **(1.1.1)**

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$= 93.66835661,\ T_{19,\,17} = 93.43468151,\ T_{19,\,18} = 92.72749686,\ T_{19,\,19}$
$= 91.52808024,\ T_{19,\,20} = 89.80438368,\ T_{19,\,21} = 87.50965922,\ T_{19,\,22}$
$= 84.58028732,\ T_{19,\,23} = 80.93248063,\ T_{19,\,24} = 76.45728972,\ T_{19,\,25}$
$= 71.01289240,\ T_{19,\,26} = 64.41230628,\ T_{19,\,27} = 56.40301890,\ T_{19,\,28}$
$= 46.63177376,\ T_{19,\,29} = 34.58153416,\ T_{19,\,30} = 19.45785256,\ T_{20,\,2}$
$= 11.29787266,\ T_{20,\,3} = 19.48363808,\ T_{20,\,4} = 25.80514549,\ T_{20,\,5}$
$= 30.85517014,\ T_{20,\,6} = 34.96251618,\ T_{20,\,7} = 38.33258831,\ T_{20,\,8}$
$= 41.10494466,\ T_{20,\,9} = 43.37990059,\ T_{20,\,10} = 45.23217708,\ T_{20,\,11}$
$= 46.71852040,\ T_{20,\,12} = 47.88224531,\ T_{20,\,13} = 48.75607715,\ T_{20,\,14}$
$= 49.36398305,\ T_{20,\,15} = 49.72235820,\ T_{20,\,16} = 49.84076825,\ T_{20,\,17}$
$= 49.72235820,\ T_{20,\,18} = 49.36398305,\ T_{20,\,19} = 48.75607715,\ T_{20,\,20}$
$= 47.88224531,\ T_{20,\,21} = 46.71852040,\ T_{20,\,22} = 45.23217708,\ T_{20,\,23}$
$= 43.37990059,\ T_{20,\,24} = 41.10494466,\ T_{20,\,25} = 38.33258831,\ T_{20,\,26}$
$= 34.96251618,\ T_{20,\,27} = 30.85517014,\ T_{20,\,28} = 25.80514549,\ T_{20,\,29}$
$= 19.48363808,\ T_{20,\,30} = 11.29787266]]$

> $LT := [seq(T_{1,\,j}, j = 1..j_{max}), seq(rhs(SolT_{1,\,i}), i = 1..N)]:$

> $with(plots):$

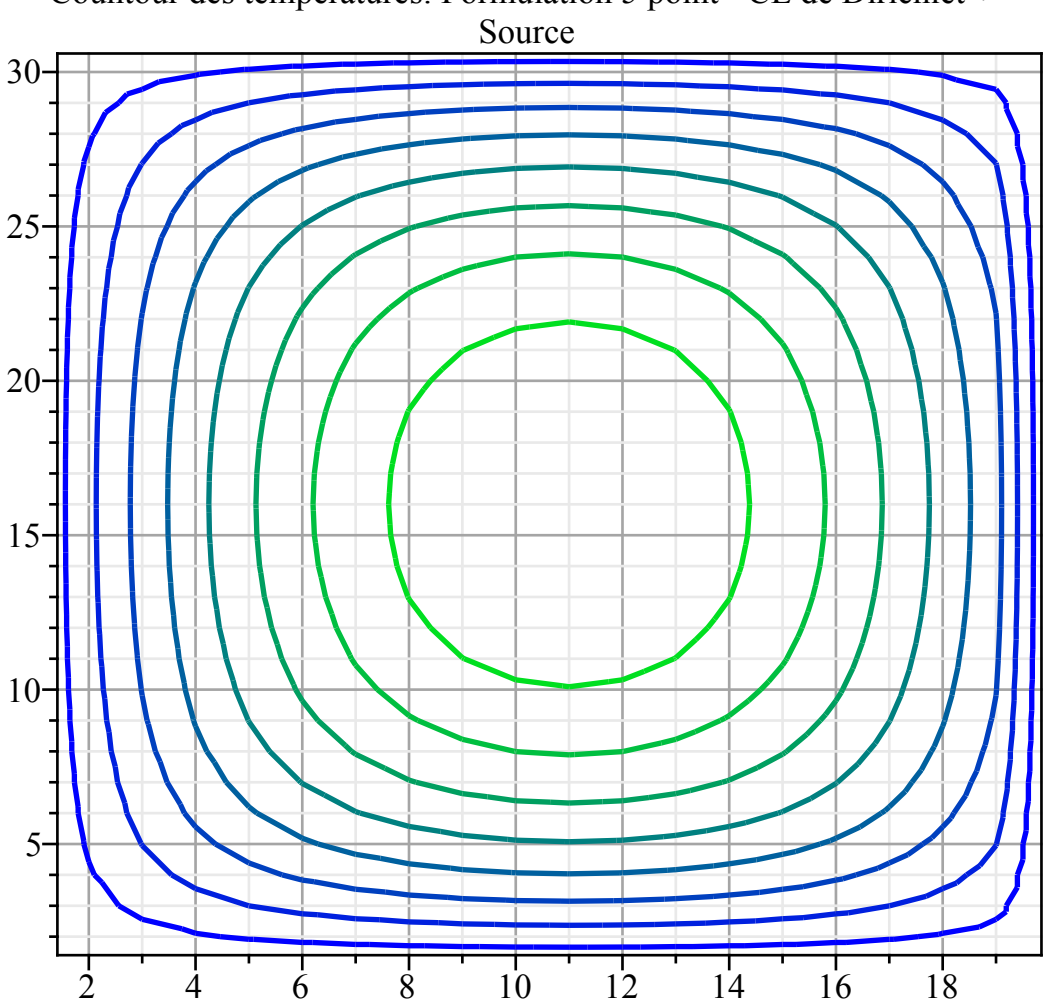
> **for** i **from** 1 **to** $i_{max} - 2$ **do** $Ns[i] := i \cdot \frac{N}{i_{max} - 2}$ **end do**:

> $GTemps := [[seq(T_{1,\,j}, j = 1..j_{max})], [T_{2,\,1}, seq(rhs(SolT_{1,\,i}), i = 1..Ns_1), T_{2,\,j_{max}}], [T_{3,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_1 + 1..Ns_2), T_{3,\,j_{max}}], [T_{4,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_2 + 1..Ns_3), T_{4,\,j_{max}}], [T_{5,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_3 + 1..Ns_4), T_{5,\,j_{max}}], [T_{6,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_4 + 1..Ns_5), T_{6,\,j_{max}}], [T_{7,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_5 + 1..Ns_6), T_{7,\,j_{max}}], [T_{8,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_6 + 1..Ns_7), T_{8,\,j_{max}}], [T_{9,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_7 + 1..Ns_8), T_{9,\,j_{max}}], [T_{10,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_8 + 1..Ns_9), T_{10,\,j_{max}}], [T_{11,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_9 + 1..Ns_{10}), T_{11,\,j_{max}}], [T_{12,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_{10} + 1..Ns_{11}), T_{12,\,j_{max}}], [T_{13,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_{11} + 1..Ns_{12}), T_{13,\,j_{max}}], [T_{14,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_{12} + 1..Ns_{13}), T_{14,\,j_{max}}], [T_{15,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_{13} + 1..Ns_{14}), T_{15,\,j_{max}}], [T_{16,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_{14} + 1..Ns_{15}), T_{16,\,j_{max}}], [T_{17,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_{15} + 1..Ns_{16}), T_{17,\,j_{max}}], [T_{18,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_{16} + 1..Ns_{17}), T_{18,\,j_{max}}], [T_{19,\,1}, seq(rhs(SolT_{1,\,i}), i = Ns_{17} + 1..Ns_{18}), T_{19,\,j_{max}}], [seq(T_{i_{max},\,j}, j = 1..j_{max})]]:$

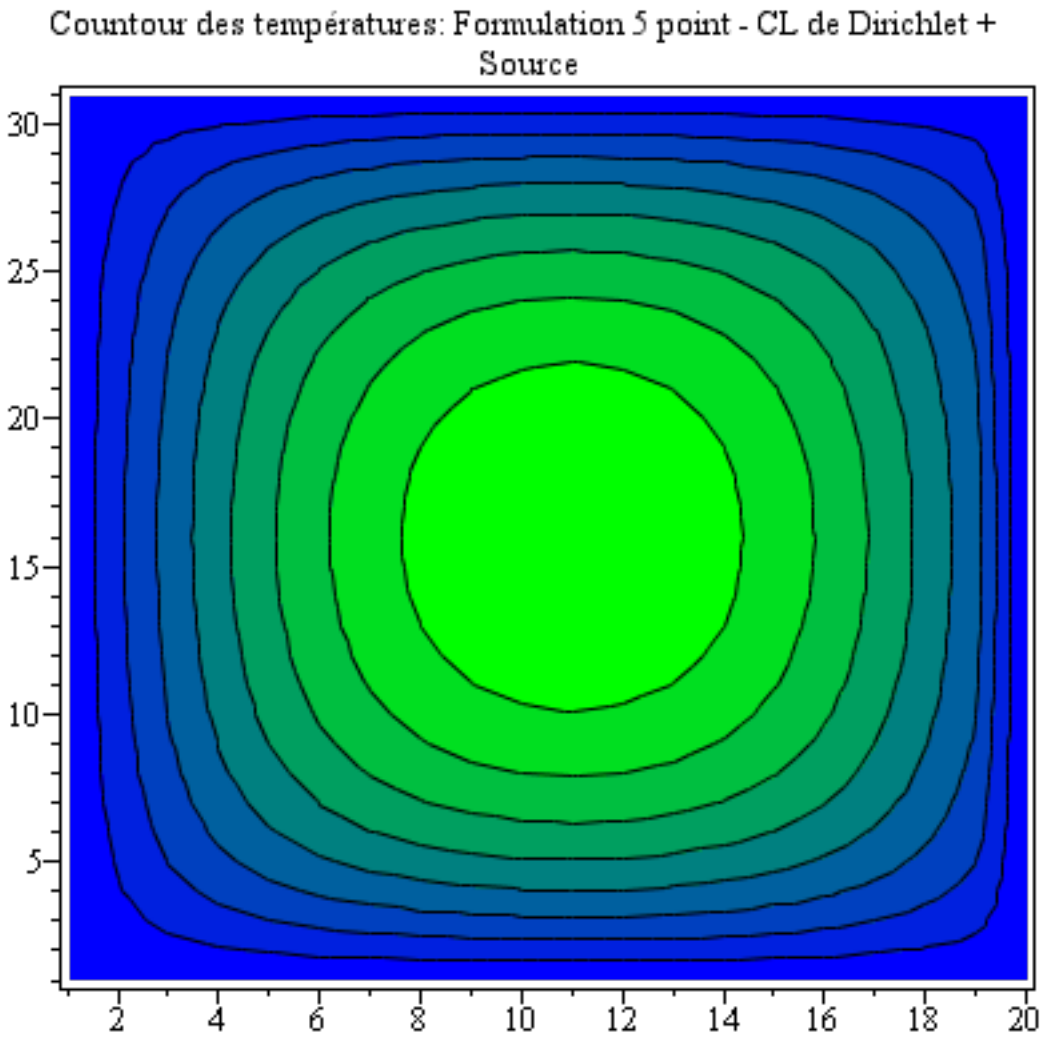
**Tracé des isothermes:**

> $listcontplot(GTemps, title$

= "Countour des températures: Formulation 5 point - CL de Dirichlet + Source", *axes* = *boxed*, *gridlines* = *true*, *thickness* = 2, *coloring* = [*blue*, *green*])




> *listcontplot*(*GTemps*, *title* = "Countour des températures: Formulation 5 point - CL de Dirichlet + Source", *axes* = *boxed*, *gridlines* = *false*, *thickness* = 1, *coloring* = [*blue*, *green*], *filledregions* = *true*)


Countour des températures: Formulation 5 point - CL de Dirichlet + Source
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